IB/05/50700

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Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

04100824.4

PRIORITY DOCUMENT

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R C van Dijk

Anmeldung Nr:
Application no.: 04100824.4
Demande no:

Anmeldetag:
Date of filing: 02.03.04
Date de dépôt:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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A process for manufacturing a high intensity discharge lamp

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

H01K9/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL
PL PT RO SE SI SK TR LI

A process for manufacturing a high intensity discharge lamp

The present invention relates to a process of manufacturing a high intensity discharge lamp comprising an elongated ceramic discharge vessel surrounded by an outer envelope and having a wall which encloses a discharge space containing an inert gas, such as xenon, and an ionizable filling, wherein at both ends in said discharge space an electrode is arranged between which a discharge arc can be maintained along a discharge path. The invention also refers to a high intensity discharge lamp manufactured according to this process.

Such a process and such a high intensity discharge lamp are widely known.

The known high intensity discharge lamp has a ceramic discharge vessel, that is a discharge vessel made of translucent polycrystalline Al_2O_3 (PCA) as a light-transmitting material. Such a discharge vessel is a complex shaped product often manufactured through conventional shaping techniques like slip casting, gel casting or pressure casting. All these casting techniques have the disadvantage that during release from the cast, the wall of the discharge vessel is considerably roughened. Such a roughened wall has the effect that scattering of light occurs at the surface of the wall. The scattering of light at the surface will hardly affect the total transmission (TT) of light of the discharge vessel. However, the total forward transmission (TFT) can be lowered considerably whereas the real in-line transmission (RIT) of the discharge vessel is completely deteriorated by such surface scattering. In order to minimize the above light-scattering effect as much as possible, the surface of the wall of the discharge vessel is polished.

Light-scattering also occurs at grain boundaries, pores and so-called second phase inclusions present in the wall of the discharge vessel, as described in an article titled "Transparent alumina: a light-scattering model" (J. Am. Ceram. Soc., 86 (3) 480-486 (2003)) of the same inventor, which is herein included by reference. In order to obtain transparent instead of translucent PCA, the average grain size should be sufficiently small, pores should be avoided or sufficiently small and second phase inclusions should be absent or sufficiently

small, as described in the prior mentionned art like J. Am. Ceram. Soc., 86 (3) 480-486 (2003) as well as in WO 04/007398, WO 04/007397 and EP 1 053983 A2.

It is the object of the invention to obviate this disadvantage of the prior art in the sense that the above described light-scattering is obviated, without using a laborious polishing step.

In order to accomplish that objective a process as described in the introduction of the description is characterized according to the invention in that in order to improve the light-transmission of the discharge vessel said process comprises the step of placing the discharge vessel in contact with a suspension of inorganic particles and allowing the suspension to enter pores in said wall and coating the surface of said wall. Particularly, the suspension is applied on the surface of the discharge vessel through a dipping or spraying operation. Using the dipping operation, the pre-sintered but still porous discharge vessel is dipped in a dilute dispersion of finely divided inorganic particles, wherein the liquid medium of the suspension, preferably water, is absorbed into the pores in the wall of the discharge vessel, giving rise to an accumulation of inorganic particles at the surface of the wall. The formed coating makes the initially rough surface smooth. The above described procedure can be applied to ceramic discharge vessels made of translucent or transparent polycrystalline materials like Al_2O_3, YAG ($Y_3Al_5O_{12}$), Y_2O_3, AlON, PLZT's (Pb-La-Zr-Ti oxides) etc. The inorganic particles are preferably chosen from the group of Al_2O_3 particles, YAG ($Y_3Al_5O_{12}$) particles, Y_2O_3 particles, AlON particles or PLZT (Pb-La-Zr-Ti oxides) particles.

In one preferred embodiment of a process in accordance with the invention the coated discharge vessel is subsequently sintered in order to allow the coating to become an integral fused part of the ceramic wall of the discharge vessel. Preferably, sintering takes place at a sintering temperature varying between 1150 and 1500°C. A higher sintering temperature may lead to so-called thermal etching, that is the surface roughens due to transport of material away from the grain boundaries at the outside and inside of the discharge vessel.

In a further preferred embodiment of a process according to the invention the inorganic particles are Al_2O_3 particles wherein Al_2O_3 grains in the sintered material have an average size varying between 0,3 and 10 micron. The porosity is then virtually zero (<0.01%). This corresponds to values of the theoretical real in-line transmission of respectively 80% down to 6% taking the wall thickness of the vessel equal to 0.3 mm and the

wavelength equal to 640 nm. The total forward transmission will in all cases be 86% if the surfaces are assumed to be sufficiently smooth so that no additional surface scattering will occur.

The invention also relates to a high intensity discharge lamp comprising an elongated ceramic discharge vessel surrounded by an outer envelope and having a wall which encloses a discharge space containing an inert gas, such as xenon, and an ionizable filling, wherein at both ends in said discharge space an electrode is arranged between which a discharge arc can be maintained along a discharge path. Such a known high intensity discharge lamp is characterized according to the invention in that a coating of said inorganic particles is made an integral fused part of the ceramic wall of the discharge vessel, wherein the integral fused part has a pore-filling effect such that the porosity of the finished ceramic wall of the discharge vessel is at least substantially smaller than 0.01%.

In one preferred embodiment of a high intensity discharge lamp in accordance with the invention the integral fused part has a surface leveling and a smoothening effect such that the finished ceramic wall of the discharge vessel has a total transmission of more than 98%, the total forward transmission is larger than 80% and the real in-line transmission is in between 6% and 80% (at a wall thickness of 0.3 mm and a wavelength of 640 nm).

In a further preferred embodiment of a high intensity discharge lamp according to the invention it is mounted in a lamp for projection purposes. The latter lamp particularly is a vehicle head lamp or a beamer.

The above and further aspects of a high intensity discharge lamp in accordance with the invention will now be explained with reference to a preferred embodiment shown in a drawing, wherein

Fig. 1 shows a lamp according to the invention is side elevation;

Figs. 2a and 2b show a microscopic upper view of the surface of the wall of the discharge vessel of the lamp shown in figure 1, polished according to the prior art (figure 2a) and dipcoated according to the invention (figure 2b), respectively.

In figure 1, the electric discharge lamp has a tubular, light transmissive ceramic discharge vessel 3 of polycrystalline aluminium oxide, and a first and a second current conductor 40, 50 which enter the discharge vessel 3 opposite each other, and each

conductor 40, 50 supports an electrode 4, 5 in the vessel 3. Said electrodes are made of tungsten and are welded to the current conductors 40, 50.

Ceramic seals 34, 35 seal the discharge vessel 3 around the current conductors 40, 50 in a gas tight manner. The discharge vessel 3 has an ionizable filling comprising xenon as a rare gas and a metal halide mixture comprising sodium and rare earth iodides. The discharge vessel 3 is surrounded by a substantially cylindrical transparent outer envelope 1.

The outer ends of current conductors 40, 50 are connected to connecting wires 8, 9 which extend outside the seals 34, 35 and through the end walls of outer envelope 1. One connecting wire 8 is connected directly to a first electric pole in mounting base 2, the other connecting wire 9 is connected to a lead back wire 19, which extends alongside the outer envelope 1 and is connected to a second electric pole in the mounting base 2. The lead back wire 19 is surrounded by a ceramic isolation shield 110.

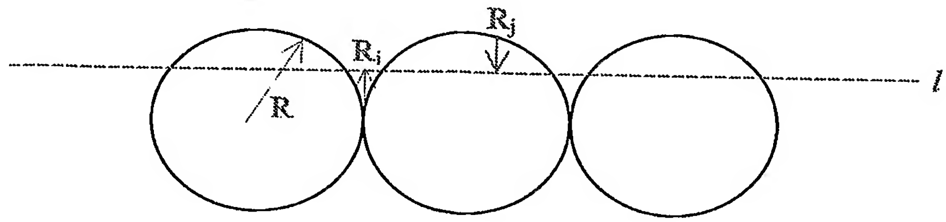
A suspension consisting of 150 mm sized alpha-alumina particles (Taimei, TM-DAR) is deagglomerated by conventional techniques like wet ball milling or ultra-sonification and stabilised with a dispersant (e.g. nitric acid). The volume fraction of the suspension ϕ_s is taken to be 0.025. A complex shaped lamp envelope consisting of the same type of particles having a porosity p of 0.35 is calcinated at 600°C in oxygen and immersed in the suspension with a volume fraction . The wall thickness y of the envelope is 1 mm. The maximum achievable coating thickness d_c when the porosity of the coating is p_c is given by the formula:

$$d_c = \frac{1/2.y.p.\phi_s}{(1-\phi_s)(1-p_c)} \qquad (1)$$

which is equal to 7 microns for the here given case. The factor ½ in equation (1) stems from the fact that the envelope is coated at the outer side as well as on the inner side. By decreasing the dipping time the coating thickness can be adjusted to any desirable value up to d_c. In the case of a thick coating d_c compared to the initial roughness $R_{a,i}$ of the discharge vessel, the roughness is determined by the size of the spheres which in the unsintered state will be minimally 1/8D, where D is the size of the spheres. The roughness R_a is defined by:

$$R_a = \frac{1}{n}\sum_n |R_i|, \qquad (2)$$

where R_i is the distance relative to the virtual middle line *l* at some place i at the coated surface, as indicated in the figure:



The lamp envelope containing the coating is sintered at 1200°C to a density of 99% without cracking or delamination of the coating. The final densification is achieved by hot isostatic pressing at 1200°C for 12 hours at 200 MPa of argon. At a sintering temperature of 1200°C thermal etching of the grain boundaries does not give rise to roughening of the surface to such extent that is causes diffuse light scattering. These bodies have become transparent after HIP, as the small average grain size (~0.5 micron) combined with the high surface smoothness leads to a very significant suppression of the light scattering.

Figures 2a and 2b show pictures taken with the help of an atomic microscope, wherein picture 2a is an upper view of a polished surface of a wall of a sintered discharge vessel (prior art) and wherein picture 2b is an upper view of a dipcoated sintered surface of a wall of a discharge vessel obtained according to the invention as described above. The R_a of the polished surface is about 7 nm, whereas the dipcoated surface is characterized by an R_a of 9 nm.

CLAIMS:

1. A process of manufacturing a high intensity discharge lamp comprising an elongated ceramic discharge vessel surrounded by an outer envelope and having a wall which encloses a discharge space containing an inert gas, such as xenon, and an ionizable filling, wherein at both ends in said discharge space an electrode is arranged between which a discharge arc can be maintained along a discharge path, characterized in that in order to improve light-transmission of the discharge vessel said process comprises the step of placing the discharge vessel in contact with a suspension of inorganic particles and allowing the suspension to enter pores in said wall and coating the surface of said wall.

2. A process according to claim 1, wherein the suspension is applied on the surface of the discharge vessel through a dipping or spraying operation.

3. A process according to claim 1 or 2, wherein the coated discharge vessel is subsequently sintered in order to allow the coating to become an integral fused part of the ceramic wall of the discharge vessel.

4. A process according to claim 3, wherein the coated discharge vessel is sintered at a sintering temperature varying between 1150 and 1500°C.

5. A process according to claim 4, wherein the inorganic particles are Al_20_3 particles and wherein Al_20_3 grains in the sintered material have an average size varying between 0,3 and 10 micron.

6. A high intensity discharge lamp comprising an elongated ceramic discharge vessel surrounded by an outer envelope and having a wall which encloses a discharge space containing an inert gas, such as xenon, and an ionizable filling, wherein at both ends in said discharge space an electrode is arranged between which a discharge arc can be maintained along a discharge path, characterized in that a coating of inorganic particles is made an integral fused part of the ceramic wall of the discharge vessel, wherein the integral fused part

has a pore-filling effect such that the porosity of the finished ceramic wall of the discharge vessel is at least substantially smaller than 0,01 %.

7. A high intensity discharge lamp according to claim 6, wherein the integral fused part has a surface leveling and a smoothening effect such that the finished ceramic wall of the discharge vessel has a total transmission of more than 98%, the total forward transmission is larger than 80% and the real in-line transmission is in between 6% and 80% (at a wall thickness of 0.3 mm and a wavelength of 640 nm).

8. A high intensity discharge lamp according to claim 6 or 7, wherein it is mounted in a lamp for projection purposes.

9. A high intensity discharge lamp according to claim 8, wherein it is mounted in a vehicle head lamp.

10 A high intensity discharge lamp according to claim 8, wherein it is mounted in a beamer.

ABSTRACT:

A process of manufacturing a high intensity discharge lamp comprising an elongated ceramic discharge vessel surrounded by an outer envelope and having a wall which encloses a discharge space containing an inert gas, such as xenon, and an ionizable filling, wherein at both ends in said discharge space an electrode is arranged between which a discharge arc can be maintained along a discharge path, with the special feature that in order to improve the light-transmission of the discharge vessel said process comprises the step of placing the discharge vessel in contact with a suspension of particles and allowing the suspension liquid to enter pores in said wall and coating the surface of said wall.

Fig. 2b

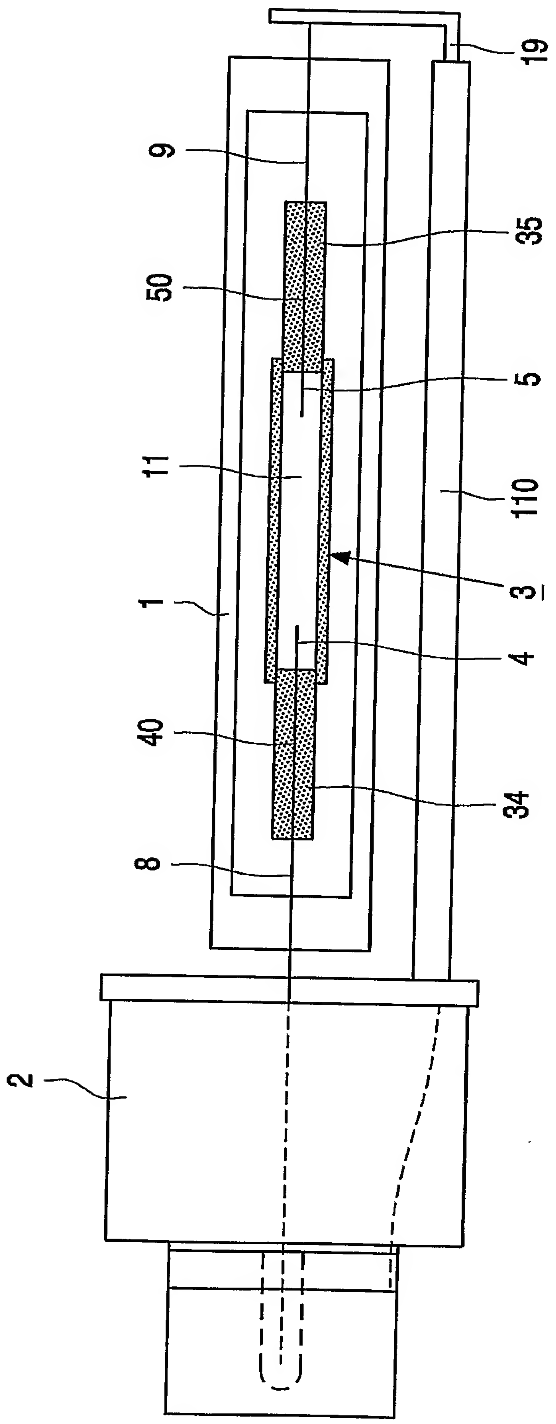


FIG. 1

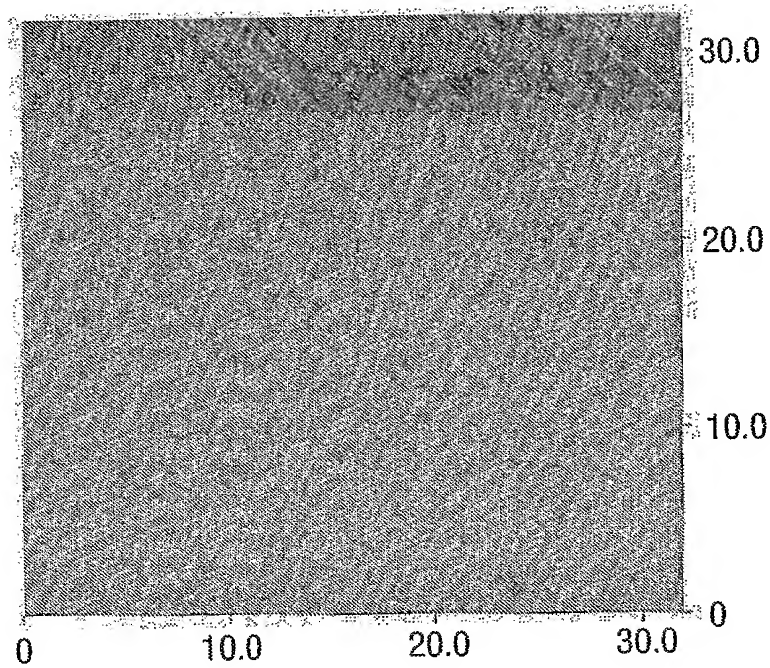


FIG.2a

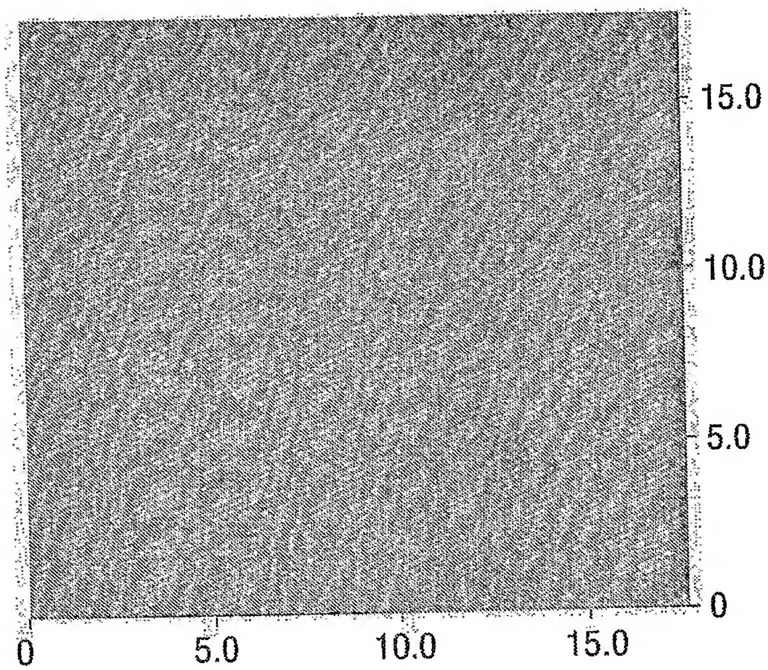


FIG.2b